

[54] **SOLID STATE BREAKERLESS IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES**

[75] Inventors: **Donald C. Loudon, Sidney; Herman E. Bernhardt, Unadilla, both of N.Y.**

[73] Assignee: **The Bendix Corporation, Southfield, Mich.**

[22] Filed: **Mar. 10, 1971**

[21] Appl. No.: **119,698**

[52] U.S. Cl. **123/148 E, 123/149 D**

[51] Int. Cl. **F02p 1/02**

[58] Field of Search **123/148 E, 149 R, 123/149 D, 148 AC; 315/209**

[56] **References Cited**

UNITED STATES PATENTS

3,356,896	12/1967	Shano.....	123/148 E
3,599,615	8/1971	Foreman	123/148 E
3,490,426	1/1970	Farr	123/149
3,619,634	11/1971	Burson.....	307/10 R
3,623,467	11/1971	Piteo.....	123/149 D

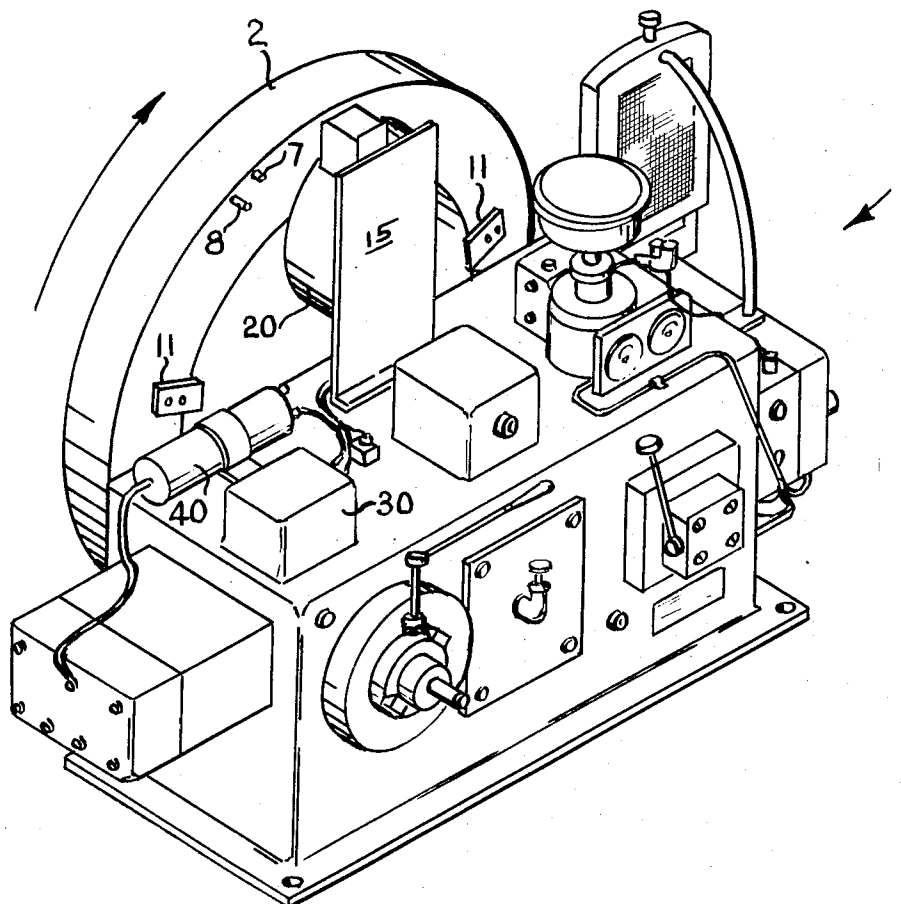
3,500,809	3/1970	Hohne et al.....	123/148 E
2,980,093	4/1961	Short.....	123/148 E
3,251,351	5/1966	Bowers.....	123/148 E

Primary Examiner—Laurence M. Goodridge
Attorney—Raymond J. Eifler and Plante, Hartz, Smith & Thompson

[57] **ABSTRACT**

A breakerless ignition system designed for installation on one and two cylinder spark ignited large horizontal engines having a flywheel. The ignition system is comprised of: a ferromagnetic flux conducting plate mounted on the flywheel of the engine; a stator assembly mounted on the engine, having a coil and a magnetic field responsive to the movement of the plate so that when the flywheel revolves and the flux conducting plate passes the stator assembly a voltage pulse is induced in the coil; and a control circuit for receiving and applying the voltage pulse induced in the coil to the spark plug at predetermined intervals. The control circuit is capable of advancing and retarding the engine spark as the speed of the engine changes.

6 Claims, 5 Drawing Figures



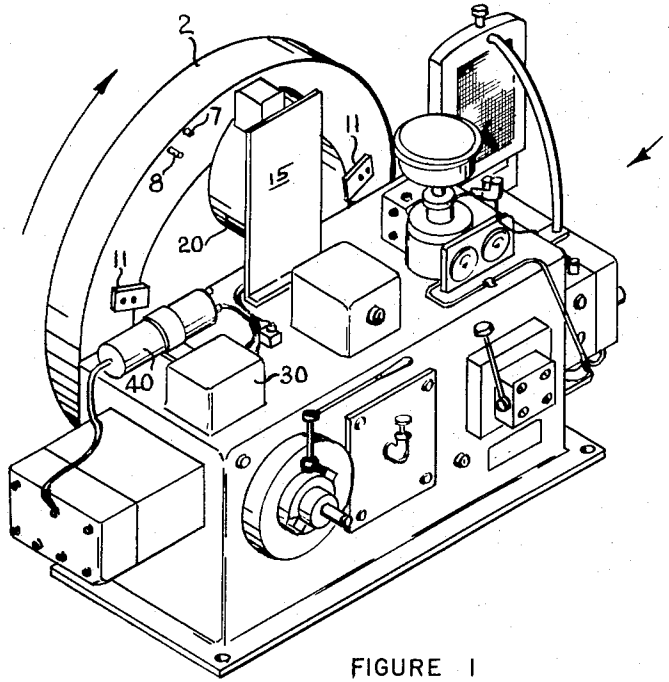


FIGURE 1

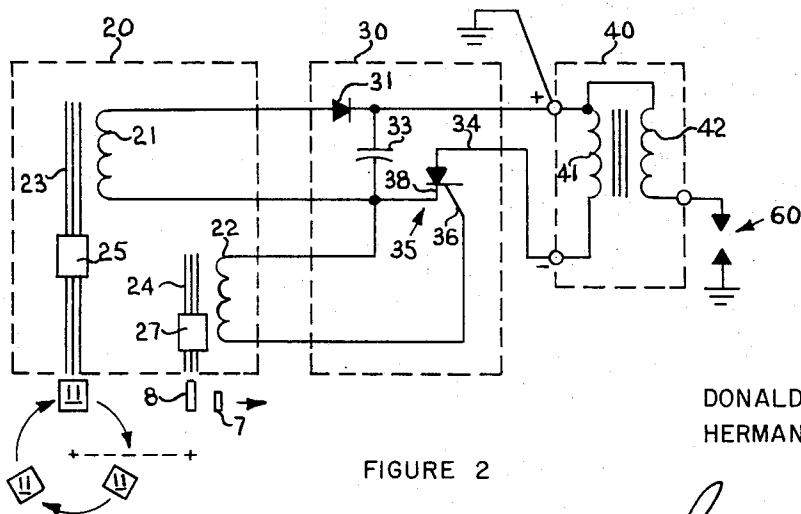


FIGURE 2

DONALD C. LOUDON
HERMAN E. BERNHARDT
INVENTOR.

BY *Raymond J. Eifler*
ATTORNEY

SOLID STATE BREAKERLESS IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to an internal combustion engine breakerless ignition system of the type having a capacitor, a means for charging the capacitor, and a means for triggering a discharge of the capacitor through an ignition coil to cause a spark across the gap of a spark plug. The invention is more particularly related to the circuit for charging the capacitor which utilizes the flywheel of the internal combustion engine as part of the means that generates the energy to be stored in the capacitor and part of the means that triggers the discharge of the capacitor through the ignition coil.

Conventional magneto ignition systems (i.e., high and low tension systems) employing breaker points and impulse couplings have a high servicing rate and require a separate engine drive, which is subject to wear. In applications such as in oil field pumping engines where one and two cylinder spark ignited large horizontal engines are operated in the open and subject to weather conditions, a high degree of reliability with a minimum amount of maintenance is required. Further, since oil field pumping engines are started by physically turning the engine flywheel, it is desirable, for the operator of the engine, to have a relatively simple apparatus that automatically retards and advances the timing of the spark as the engine changes its speed. The speed of the engine changes as the load is varied and during startup when the engine is hand cranked.

SUMMARY OF THE INVENTION

This invention provides a breakerless ignition system that utilizes the flywheel of the internal combustion engine to help generate electrical energy that charges a capacitor and triggers the discharge of the capacitor through an ignition coil. This arrangement eliminates the need for a d.c. battery or external a.c. power source and increases engine performance by advancing or retarding the engine spark timing as the speed of the engine changes.

The invention is a breakerless ignition system for an internal combustion engine characterized by a generator circuit that nonmagnetized ferromagnetic flux conducting plates mounted on the flywheel of the internal combustion engine to generate voltage pulses which are stored in a capacitive network before application to the internal combustion engine spark plug. In one embodiment of the invention, the ignition system comprises: a nonmagnetized magnetic flux conducting member or plate mounted on the flywheel of the internal combustion engine; a stator assembly including a coil and a magnetic field responsive to the movement of the plate on the flywheel mounted adjacent to the flywheel so that when the flywheel revolves and the plate passes the stator assembly, a voltage pulse is induced in the coil; and control means for receiving and applying the voltage pulse from the coil to the spark plug of the internal combustion engine in a predetermined manner. This embodiment of the invention is further characterized by the fact that the stator assembly includes a generally C-shaped magnetic flux conducting member wherein one of the extensions includes a permanent magnet disposed therein while the other extension includes a coil disposed around a portion thereof.

Extensive research development and field testing, over a period of several years, led to the adaptation of a system that employed a permanent magnet in a "C" shaped stator assembly and a nonmagnetized magnetic flux conductor plate in the rotating assembly. Although this is contrary to general electromechanical generator practices, where the magnet is part of the rotating assembly, it provided the inventor with a more versatile generator. For example, it is cheaper and safer to add flux conducting plates to the flywheel than to add magnets. Since there are no magnets exposed, there is no chance of a magnet picking up stray metal and propelling the metal through the air once the flywheel begins rotating.

Accordingly, it is an object of this invention to provide a breakerless ignition system for an internal combustion engine having a flywheel.

It is another object of this invention to provide a solid state breakerless ignition system that does not require a power supply.

It is another object of this invention to improve the reliability of ignition systems on internal combustion engines used outdoors.

It is still another object of this invention to reduce the maintenance work required on an ignition system of an internal combustion engine.

It is a still further object of the present invention to improve the versatility of existing solid state breakerless ignition systems.

It is yet another object of this invention to provide a breakerless ignition system with an automatic spark advance control.

It is still yet another object of this invention to provide a dependable low cost breakerless ignition system that facilitates engine starting.

It is a further object of this invention to improve the safety of starting systems for oil field pumping engines.

The above and other objects and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings and claims which form a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a breakerless ignition system in combination with an internal combustion engine that has a flywheel.

FIG. 2 is a simplified schematic diagram of a breakerless ignition system.

FIG. 3 is a more detailed schematic diagram of a breakerless ignition system for internal combustion engines.

FIG. 4 is an illustration of a stator assembly having a C-shaped configuration that may be mounted on an internal combustion engine to produce electrical energy in response to the movement of the engine flywheel.

FIG. 5 is an end view of the stator assembly shown in FIG. 4.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, FIG. 1 illustrates an internal combustion engine 1 having a flywheel 2 that utilizes the principles of this invention.

The breakerless ignition system used in combination with the internal combustion engine 1 comprises: one or more magnetic flux conducting plates 11 (e.g. cold rolled steel) mounted on the flywheel 2; a stator assembly

bly 20 mounted adjacent the flywheel 2 by mounting bracket 15; an ignition coil 40 for supplying energy to the spark plug (not shown); and a control circuit 30, which in conjunction with the triggering pins, 7 and 8, and stator assembly 20, properly synchronizes the application of the voltages applied to the ignition coil to the rotation of the engine. The trigger pins 7 and 8 are mounted at a greater radial distance from the center of the flywheel 2 than the plates 11 to physically separate and, therefore, isolate the triggering pins 7 and 8 from the charging circuit but not the trigger circuit in the stator assembly 20.

The stator assembly 20 is mounted on the engine 1 so that it is adjacent to and in close proximity to the flywheel 2. The spacing between the stator assembly 20 and the flywheel 2 is such that when a trigger pin 7 or 8, or a plate 11 is immediately opposite of the stator assembly 20 they will respectively affect the magnetic circuits of the stator assembly to produce a trigger pulse or a charging pulse. Although plates 11 are shown mounted on the flywheel 2, the flywheel 2 can be cast to include one or more raised surfaces that are flux conducting paths and thereby eliminate the need for mounting separate plates 11. However, the plates 11 add to the versatility of the system because additional plates 11 may be added to the flywheel to increase the total electrical energy generated in the ignition system per revolution of the flywheel 2.

FIG. 2 is a schematic diagram that illustrates how the movement of a plate 11 and a trigger pin 7 or 8 past the stator assembly 20 produces voltage pulses in the charging circuit and trigger circuit. For convenience, the breakerless ignition circuit is divided into a stator assembly circuit 20, a control circuit 30, and an ignition coil circuit 40. The electrical components contained in each circuit and in the corresponding assembly shown in FIG. 1 are shown within the dotted lines.

The stator assembly 20 includes a permanent magnet 25, flux conducting laminations 23, a charging coil 21 in electromagnetic circuit relationship with the magnet 25 and laminations 23, a trigger coil 22, magnet 27, and flux conducting laminations 24 in electromagnetic circuit relationship with the coil 22 and magnet 27. The charging coil 21 is electromagnetically responsive to the passage of a plate 11 and the trigger coil 22 is electromagnetically responsive to the passage of a trigger pin 7 or 8.

The control circuit 30 comprises a solid state rectifier 31, a charging capacitor 33, and a silicon controlled rectifier switch 35 having its gate 36 and cathode 38 in circuit relationship with trigger coil 22, its anode 34 in circuit relationship with the ignition coil circuit 40 and its cathode 38 in circuit relationship with charging coil 21 and charging capacitor 33.

The ignition coil circuit 40 includes a primary winding 41 which has one lead in circuit relationship with charging capacitor 33 and rectifier 31 and the other lead in circuit relationship with the anode 34 of the silicon controlled rectifier switch 35. The secondary winding 42 of the ignition coil circuit 40 is connected in circuit relationship with spark plug 60.

The system depicted in FIG. 2 is completely free of moving parts, and each assembly is hermetically sealed to prevent adverse operation during out-of-doors use. As the magnetic flux conducting plates 11 pass opposite the stator assembly 20 they produce changes in the magnetic flux associated with that portion of the stator

assembly 20 which includes the coil 21, magnet 25 and laminations 23. In this embodiment, the stator assembly charging coil 21, laminations 23, and permanent magnet 25 generate two voltage pulses (a positive and negative excursion) each time a plate 11 passes the stator assembly 20. Rectification of this primary output to pulsating direct current is accomplished by blocking diode 31 in the control circuit 30. The energy generated by the interaction of the stator assembly charging coil 21 with the moving plates 11 is then stored in capacitor 33 of control circuit 30. The energy remains in capacitor 33 until the capacitor is discharged by triggering the silicon controlled rectifier switch 35 "ON". Each time the switch 35 triggers "ON", it produces an electrical discharge across the spark plug gap 60. After the capacitor 33 discharges, the SCR switch 35 returns to the "OFF" state allowing the storage capacitor 33 to recharge.

Spark timing is accomplished electronically by trigger pins 7 or 8 positioned on the side of the flywheel 2. As a trigger pin 7 or 8 passes the trigger coil 22, it generates a small voltage pulse across the coil 22 which triggers (turns on) the silicon controlled rectifier 35 thereby allowing the capacitor 33 to discharge through the primary coil 41 of the ignition coil 40. This creates an instantaneous high voltage in the secondary winding 42 of the ignition coil 40 that fires the spark plug 60. In this embodiment coils 21 and 22 and their associated magnetic circuit components are part of the same stator assembly 20. Alternately, they could be separate assemblies.

Advance and retard timing is obtained through the use of two trigger pins 7 and 8 angularly spaced one from the other in the direction of rotation of the flywheel. The spark timing is automatically advanced when speed is increased and automatically retarded when speed decreases. This is accomplished by locating the first trigger pin 7 (in the direction of rotation) so that it has a greater clearance as it passes the coil 22 and laminations 24 than the second trigger pin 8. At low speeds, pin 7 does not generate a voltage sufficient to trigger SCR 35. However, as the angular velocity of the flywheel increases the trigger pulses generated by the first trigger pin 7 passing the trigger coil 22 increase to sufficient magnitude to trigger the solid state control device 35. At starting speeds, the trigger pin 8 more closely spaced from the coil 22 that pin 7, generates a voltage in the coil 22 to turn the SCR 35 "ON". However, as the speed of the fly-wheel 2 increases, the rate of change of flux with respect to time caused by the passing of the first trigger pin 7 increases to a value sufficient to generate a voltage that gates SCR 35 "ON".

FIG. 3 is a schematic diagram that is similar to the circuit shown in FIG. 2 with the exception of certain additional desirable features. In this schematic, components performing the same function as those described in FIG. 2 will have the same number as those components shown in FIG. 2.

In this circuit, a voltage tripler circuit is employed to increase the maximum value of the voltage applied to the ignition coil primary winding 41 upon discharge of capacitor 33. The voltage tripler circuit is comprised of capacitor 33 and diode 31 in circuit relationship with blocking diodes 72 and 73 and capacitors 71 and 74. The diodes 31, 72 and 73 in combination with capacitors 33, 71 and 74 produce a d.c. voltage equal to ap-

proximately three times the peak input voltage generated across coil 21.

A diode 75 connected in parallel across capacitor 33 has its cathode connected to the positive side of capacitor 33. This diode 75, which could also be a zener diode, prevents capacitor 33 from acquiring a residual negative charge as a result of the final electromagnetic action of primary winding 41 of the ignition coil 40 after the capacitor 33 discharges therethrough.

Gate to cathode resistor 76 and diode 77 limits the leakage current that flows between the gate 36 and cathode 38 of SCR 35 when the SCR 35 is "OFF". The diode 77 and resistor 76 also prevents spurious noise signals in the trigger coil 22 circuit from turning the SCR "ON".

FIG. 4 illustrates a generally C-shaped configuration of that portion of the stator assembly 20 which includes the charging coil 21, the magnet 25, and the flux conducting laminations 23. Although other arrangements such as an E-shaped assembly can be used, it is preferred that this particular C-shaped configuration be used so that it is not necessary to have magnets mounted on the flywheel. In this preferred embodiment, the charging coil 21 is arranged about one leg of the laminations 23 while a permanent magnet 25 is disposed in the other leg of the laminations 23. In this way, when a plate 11 passes the stator assembly 20, the flux in the magnetic circuit varies, producing an output voltage at wires A and B of charging coil 21.

FIG. 5 is a side view of the C-shaped portion of stator assembly 20 which shows the location of permanent magnet 25 in one leg of the assembly. The laminations 23 and magnet 25 are held in place by pins 9 and non-magnetic retaining plates 8.

While a preferred embodiment of the invention has been disclosed, it will be apparent to those skilled in the art that changes may be made to the invention as set forth in the appended claims and, in some cases, certain features of the invention may be used to advantage without corresponding use of other features. Accordingly, it is intended that the illustrative and descriptive materials herein be used to illustrate the principles of the invention and not to limit the scope thereof.

Having described the invention, what is claimed is:

1. In combination with an internal combustion engine of the type having a flywheel and a spark plug to ignite fuel in the engine, a breakerless ignition system comprising:

a non-magnetized magnetic flux conducting plate mounted on the flywheel of said engine;

a stator assembly having a coil and a magnetic field responsive to the movement of said plate, said stator assembly including a generally C-shaped configuration comprised of:

a first magnetic flux conducting member;

a second magnetic flux conducting member in generally parallel relationship to and spaced from said first member;

a third magnetic flux conducting member disposed between and generally perpendicular to said first and second members to form said generally C-shaped configuration; and wherein said stator coil is disposed around a portion of said first member; and wherein said second member includes a permanent magnet disposed so that the magnet's polar

axis is perpendicular to said third member;

means for mounting said stator assembly adjacent to the flywheel so that when the flywheel revolves and said plate passes said stator assembly a voltage pulse is induced in the coil; and

control means for receiving and applying the voltage pulse from said coil to said spark plug in a predetermined manner.

2. The combination as recited in claim 1 wherein said control means includes an ignition coil for amplifying the pulses received from said stator coil before applying them to said spark plug, said ignition coil having a primary winding in circuit relationship with said stator coil and a secondary winding in circuit relationship with said spark plug.

3. The combination as recited in claim 2 wherein said control means comprises:

a capacitor in circuit relationship with said stator coil and the primary winding of said ignition coil;

a circuit for periodically discharging said capacitor through the primary winding of said ignition coil, said circuit including a solid state electronic switching device selectively rendered electrically conductive to permit discharge of said capacitor through the primary winding of said ignition coil and nonconductive to permit charging of said capacitor by the voltage pulses produced by said stator coil, said switching device having an anode, a cathode and a control electrode; and

trigger means for controlling said solid state switching device, said trigger means including means for generating trigger pulses having a repetition rate dependent upon the angular velocity of said flywheel and out of phase with said voltage pulses produced by said stator coil.

4. The combination as recited in claim 3 wherein said means for generating trigger pulses includes a metal trigger pin mounted on said flywheel and a second stator assembly having a coil and a permanent magnet in electromagnetic relationship, said second stator coil electrically responsive to movement of said trigger pin and in circuit relationship with the cathode and control electrode of said solid state switching device, said second stator assembly mounted adjacent said flywheel so that when said flywheel revolves and said metal trigger pin passes said second stator coil, a voltage is induced in said coil causing the solid state switching device to conduct thereby permitting the capacitor to discharge through the primary winding of said ignition coil and supply energy to said spark plug.

5. The combination as recited in claim 4 wherein said means for generating trigger pulses includes a second metal trigger pin angularly spaced from said first trigger pin in the direction of rotation of the flywheel, said second trigger pin having a greater clearance from said second stator assembly than said first trigger pin so that as the angular velocity of said flywheel increases the trigger pulses generated by said second trigger pin passing said second stator assembly increases to sufficient magnitude to trigger said solid state control device.

6. The combination as recited in claim 5 wherein there are a plurality of nonmagnetized flux conducting plates mounted on the flywheel.

* * * * *